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FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 09/937904 0696-0183P

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): ~~09/937904~~ NEW

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI00/00278	March 31, 2000	April 1, 1999

TITLE OF INVENTION: A PROCESS FOR EVAPORATIONG A SOLUTION AND AN EVAPORATOR FOR USE IN THE PROCESS

APPLICANT(S) FOR DO/EO/US: RAMM-SCHMIDT, Leif; MYREEN, Kari; LAAIANIEMI, Matti

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39 (1).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau. WO 00/59598
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is transmitted herewith.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4)
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 20. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98, Form PTO-1449(s), and International Search Report (PCT/ISA/210) with 5 cited document(s).
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:
    1.) PCT Substitute Claims Letter w/ International Preliminary Examination Report (PCT/IPEA/409) and amended claims
    2.) PCT Request
    3.) Four (4) sheets of Formal Drawings

U.S. APPLICATION NO (if known, see 37 CFR 1 5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
NEW 09/937904	PCT/FI00/00278	0696-0183P

21. ☒ The following fees are submitted:

		CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):			
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.	**$1,040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	**$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO.	**$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	**$710.00**		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).	**$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		**$ 1040.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		**$ 130.00**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	30 - 20 =	10	X **$18.00**	**$ 180.00**	
Independent Claims	2 - 3 =	0	X **$84.00**	**$ 0**	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		Yes	+ **$280.00**	**$ 280.00**	
TOTAL OF ABOVE CALCULATIONS =				**$ 1630.00**	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				**$ 0**	
SUBTOTAL =				**$ 1630.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)).			+	**$ 0**	
TOTAL NATIONAL FEE =				**$ 1630.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property			+	**$ 0**	
TOTAL FEES ENCLOSED =				**$ 1630.00**	
				Amount to be: refunded	**$**
				charged	**$**

a. ☒ A check in the amount of $ **1630.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account. No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-2448.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:
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Date: October 1, 2001

By _____
Andrew D. Meikle, #32,868

/cqc

PATENT
0696-0183P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant: RAMM-SCHMIDT, Leif et al. Conf.:

Int'l. Appl. No.: PCT/FI00/00278

Appl. No.: New Group:

Filed: October 1, 2001 Examiner:

For: A PROCESS FOR EVAPORATING A SOLUTION AND AN EVAPORATOR FOR USE IN THE PROCESS

PRELIMINARY AMENDMENT

BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, DC 20231

October 1, 2001

Sir:

The following Preliminary Amendments and Remarks are respectfully submitted in connection with the above-identified application.

AMENDMENTS

IN THE SPECIFICATION:

Please amend the specification as follows:

Before line 1, insert --This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/FI00/00278 which has an International filing date of March 31, 2000, which designated the United States of America.--

IN THE CLAIMS:

Please amend the claims as follows:

3. (Amended) A method according to Claim 1 or 2, characterized in that the solution to be recycled is fed underneath parallel lamellas (16) or an intermediate bottom (27) provided with ports (28-30), which are located in the liquid distribution space (14), so that the flow channels (22) between the lamellas, and the precipitate (23) is separated from the flow under the effect of centrifugal force.

4. (Amended) A method according to Claim 1 or 2, characterized in that the precipitate is lead through an exhaust pipe (21) to a settling apparatus (25), where the precipitate is separated from the liquid phase the comes with it, after which the liquid phase is connected to the recirculation flow of the solution that takes place in the evaporator.

5. (Amended) A method according to Claim 1 or 2, characterized in that the evaporator is a film evaporator consisting of heat exchanger elements (3) made of flexible film material, such as plastic film.

9. (Amended) An evaporator according to Claim 6 or 7, characterized in that the recirculation line (11) is attached to one end of the elongated liquid distribution space (14), and that the exhaust pipe (21) for the precipitate starts from the opposite end of the liquid distribution space.

10. (Amended) An evaporator according to Claim 6 or 7, characterized in that the bottom of the liquid distribution space (14) is slanted downwards towards the exhaust pipe (21).

11. (Amended) An evaporator according to Claim 6 or 7, characterized in that the liquid distribution space (14) converges in a sphenoid or conic form towards the exhaust pipe (21).

12. (Amended) An evaporator according to Claim 6 or 7, characterized in that the supply units comprises distributive nozzles (31) that start from the liquid distribution space (14) and spread out like fans, each one of them feeding solution to several parallel gaps between the heat transmission surface (4) of the heat exchanger elements (3), evaporation taking place in the gaps.

13. (Amended) An evaporator according to Claim 6 or 7, characterized in that the trough-like liquid distribution space (14) is provided with parallel, slanting lamellas (16) between which the solution is allowed to flow upwards.

14. (Amended) An evaporator according to Claim 6 or 7, characterized in that the trough-like liquid distribution space (14) comprises an intermediate bottom (27) that divides it into a lower and upper part (17,18) that the recirculation line (11) is attached, in the lateral direction, to the lower part (17) of the liquid distribution space, and that the intermediate bottom comprises ports, through which the solution is allowed to flow to the upper part (18) of the space at the same time as the precipitate (23) ends up in the exhaust pipe (21) that starts from the bottom of the space.

16. (Amended) An evaporator according to Claim 13, characterized in that the trough-like liquid distribution space (14) is provided with a dam plate (15), over which the solution flows as an overflow to the supply units (6) of the parallel heat exchanger elements.

17. (Amended) An evaporator according to Claim 6 or 7, characterized in that the exhaust pipe (21) leads to settling apparatus (24), which separates the precipitate from the liquid phase that comes with it, and that the settling apparatus is connected by using a line (26), to the recirculation line (11) in order to join that separated liquid phase to the recirculation flow in the evaporator.

REMARKS

The specification has been amended to provide a cross-reference to the previously filed International Application. The claims have also been amended to delete improper multiple dependencies and to place the application into better form for examination. Entry of the present amendment and favorable action on the above-identified application are earnestly solicited.

Attached hereto is a marked-up copy of the changes made to the application by this Amendment.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By _____
Andrew D. Meikle, #32,868

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ADM/cqc
0696-0183P

Attachment: Version With Markings Showing Changes Made

(Rev. 01/22/01)

VERSION WITH MARKINGS SHOWING CHANGES MADE

The specification has been amended to provide cross-referencing to the International Application.

The claims have been amended as follows:

3. (Amended) A method according to [any of the preceding Claims]Claim 1 or 2, characterized in that the solution to be recycled is fed underneath parallel lamellas (16) or an intermediate bottom (27) provided with ports (28-30), which are located in the liquid distribution space (14), so that the flow channels (22) between the lamellas, and the precipitate (23) is separated from the flow under the effect of centrifugal force.

4. (Amended) A method according to [any of the preceding Claims]Claim 1 or 2, characterized in that the precipitate is lead through an exhaust pipe (21) to a settling apparatus (25), where the precipitate is separated from the liquid phase the comes with it, after which the liquid phase is connected to the recirculation flow of the solution that takes place in the evaporator.

5. (Amended) A method according to [any of the preceding Claims]Claim 1 or 2, characterized in that the evaporator is a film evaporator consisting of heat exchanger elements (3) made of flexible film material, such as plastic film.

9. (Amended) An evaporator according to [any of Claims 6 to 8]Claim 6 or 7, characterized in that the recirculation line (11) is attached to one end of the elongated liquid distribution space (14), and that the exhaust pipe (21) for the precipitate starts from the opposite end of the liquid distribution space.

10. (Amended) An evaporator according to [any of Claims 6 to 9]Claim 6 or 7, characterized in that the bottom of the liquid distribution space (14) is slanted downwards towards the exhaust pipe (21).

11. (Amended) An evaporator according to [any of Claims 6 to 10]Claim 6 or 7, characterized in that the liquid distribution space (14) converges in a sphenoid or conic form towards the exhaust pipe (21).

12. (Amended) An evaporator according to [any of Claims 6 to 12]Claim 6 or 7, characterized in that the supply units comprises distributive nozzles (31) that start from the liquid distribution space (14) and spread out like fans, each one of them feeding solution to several parallel gaps between the heat transmission surface (4) of the heat exchanger elements (3), evaporation taking place in the gaps.

13. (Amended) An evaporator according to [any of Claims 6 to 12]Claim 6 or 7, characterized in that the trough-like liquid distribution space (14) is provided with parallel, slanting lamellas (16) between which the solution is allowed to flow upwards.

14. (Amended) An evaporator according to [any of Claims 6 to 12]Claim 6 or 7, characterized in that the trough-like liquid distribution space (14) comprises an intermediate bottom (27) that divides it into a lower and upper part (17,18) that the recirculation line (11) is attached, in the lateral direction, to the lower part (17) of the liquid distribution space, and that the intermediate bottom comprises ports, through which the solution is allowed to flow to the upper part (18) of the space at the same time as the precipitate (23) ends up in the exhaust pipe (21) that starts from the bottom of the space.

16. (Amended) An evaporator according to [any of Claims 13 to 15]Claim 13, characterized in that the trough-like liquid distribution space (14) is provided with a dam plate (15), over which the solution flows as an overflow to the supply units (6) of the parallel heat exchanger elements.

17. (Amended) An evaporator according to [any of Claims 6 to 16]Claim 6 or 7, characterized in that the exhaust pipe (21) leads to settling apparatus (24), which separates the precipitate from the liquid phase that comes with it, and that the settling

line (11) in order to join that separated liquid phase to the recirculation flow in the evaporator.

A process for evaporating a solution and an evaporator for use in the process

The object of the invention is a method for evaporating a solution, comprising the spreading of the solution on the heat transmission surfaces of the parallel, plate heat exchanger elements of an evaporator to run from the top downwards, the solution being fed from a liquid distribution space common to both elements; the solution that remains on the heat transmission surfaces without evaporating and the precipitate that is formed in connection with evaporation are removed from the lower end of the evaporator, and the solution that has not evaporated is recycled back to the heat transmission surfaces for re-evaporation. Furthermore, the invention is directed at the evaporator used in the said method.

The publications FI 79948 and 86961 describe heat exchangers made of bag-like heat transmission elements consisting of film material, such as plastic, which are suitable, among others, for distillation and for concentrating various suspensions. In the heat exchanger, the elements are tied against one another to form a pack, in which water is lead to the outer surfaces of the elements to be evaporated, and then the evaporated steam is compressed to a higher pressure and temperature by a compressor and conducted inside the elements to constitute heating steam, which in the heat transmission is condensed back into water.

The degree of saturation of the components dissolved in the concentration of solutions by evaporation grows, and when the saturation point is exceeded, precipitation results. As examples, we could mention the calcium oxalate precipitated from the bleaching effluents of chemical pulp, the calcium carbonate, calcium sulphate, and calcium silicate, as well as possible iron compounds precipitated from subsoil waters, the denaturised proteins precipitated from the waster water of the food industry, and salts such as gypsum and iron salts or hydroxides precipitated from mineral-bearing waste water. In the heat exchangers according to the publications mentioned above, the precipitate formed on the film surfaces, as well as the solid matter contained by the suspensions that are treated, are easily accumulated into the form of a cake between the bag-like elements, impeding heat transmission and the flow of liquid and steam, which is why the gaps between the elements must perhaps be cleaned from time to time. However, the FI application No. 970273 discloses an evaporator with improved shapes of elements, so that, during evaporation, the precipitate or other solid matter fall from between

the elements onto the bottom of the evaporator; in other words, regarding the elements, the evaporator is self-cleaning.

In evaporators, where the portion of the treated solution or suspension that has not evaporated is recycled back onto the heat transmission surfaces to achieve a sufficient degree of evaporation, one problem remains: the solid matter falling from between the elements onto the bottom of the evaporator gets into the liquid circulation flow, possibly blocking the narrow liquid distribution channels at the upper ends of the elements, from where liquid is fed onto the surfaces of the elements. As the efficiency of evaporation is crucially dependent on an even spreading of liquid onto the heat transmission surfaces of the elements, the precipitate and other solid matter must be removed from the circulation flow in order to prevent blockages in the feeding channels.

The problem with blocking could be alleviated by simply providing the circulation line with a separation device, such as a filter, a cyclone, or a sedimentator, which would separate the precipitate from the liquid before it is recycled back to the evaporation phase, as mentioned above. However, from the point of view of space utilization and costs, this solution would be disadvantageous; in addition, the pressure loss caused by the separator increases the use of energy needed for pumping. If the separator is located at the suction face of the circulation pump, the pressure loss can cause cavitation of the pump. Furthermore, the solid matter coming off from the walls of the recycling tube system subsequent to the separator, which would end up in the liquid distribution channels of the elements, remains a problem.

To avoid the disadvantages mentioned above, according to the invention, the separation of the precipitate or other solid matter from the solution recycled to re-evaporation is arranged so as to take place in connection with the distribution of the liquid to the feeding flow leading to the heat transmission surfaces of the various elements of the evaporator. The method according to the invention is characterized in that the recycled solution is fed to the liquid distribution space so that the precipitate in the solution is separated in the space under the effect of its weight and/or kinetic energy at the same time as the flow of the solution is directed upwards, that the precipitate is removed to the exhaust pipe that starts from the bottom of the space, and that the solution is conducted from the space to the feeding units leading to the heat transmission surfaces of the elements.

Regarding the essential features of the evaporator according to the invention, which can be used to implement the evaporation method described above, we refer to the appended Claims, Claim 7 in particular.

The invention is suitable for film evaporators in particular, in which bag-like heat exchanger elements consist of flexible film material, such as plastic film. In these, the precipitate can come off from the heat transmission surfaces not only in connection with washing, but also during a run; in other words, they can be self-cleaning, so that it is essential to remove the loosened precipitate from the solution circulation flow.

According to the invention, by connecting the separation of precipitate to the solution feeding that goes to the heat transmission surfaces it is possible to remove, from the solution, the solid matter originating in not only the heat transmission surfaces but also the recycling tube systems, just before the feeding phase, which is the most crucial phase with regard to blocking. The separation of the precipitate thus arranged does not impede the washing of the evaporator, where large amounts of loosening precipitate go to the wash water, which is removed from the bottom of the evaporator. With respect to the utilization of space and the functionality, it is preferable to locate the liquid distribution space inside the evaporator jacket.

The liquid distribution space can preferably be designed as an elongated duct, one end of which is connected to the recirculation line of the solution, and the opposite end is provided with an exhaust pipe for the precipitate. In this solution, the feeding units leading to the heat transmission surfaces are preferably distributive nozzles that begin from the liquid distribution space and spread out like fans, and each one of them feeds solution to several parallel gaps between the heat transmission surfaces of the heat exchanger elements, where evaporation takes place. Before joining the liquid distribution space, the recirculation line preferably forms a curve directed towards the space downwards from above, which causes the centrifugal force to press the precipitate to the circumference of the line and to the bottom of the liquid distribution space, which is its extension, already at the stage when the solution is coming. The precipitate then drifts, in the form of a bottom flow, along the shortest route from the space to the exhaust pipe.

Alternatively, the liquid distribution space can consist of an elongated trough, which can be provided with parallel, slanting lamellas, under which the recycled solution is fed and between which the solution can flow upwards. In that case, the flow of the solution winds into the flow channels between the lamellas, which are

directed upwards, while the precipitate at the same time is separated from the flow under the effect of centrifugal force. This separation based on the kinetic energy of the precipitate is effective especially, when the lamellas are sloped upstream with respect to the incoming direction of the circulated flow. The said curvature of the recirculation line of the solution is advantageous also in this application.

In addition to or instead of the kinetic energy of the precipitate particles, gravitational force can be utilized in the separation of the precipitate by arranging laminar flowing conditions in the liquid distribution space so that the space with its slanting lamellas works as a lamellate settling apparatus. The sedimentation of the particles is advanced, if the bottom of the liquid distribution space is downwards slanting in the incoming direction of the circulated flow.

Furthermore, it is preferable to design the liquid distribution space or its lower part so that it converges, in the incoming direction of the circulated flow, in a sphenoid or conic form towards the exhaust pipe that starts from the opposite side of the space to the recirculation line. In that case, the speed of the stream flow can be kept essentially stable so that, in the space, an even upward flow and an even distribution of liquid to the feeding units of the various heat transmission elements is provided.

Instead of the said slanting lamellas, the trough-like liquid distribution space can be provided with an intermediate bottom that divides it into a lower and upper part, comprising the necessary ports for up flow. The ports can be slanting and the walls defining them can have a more or less lamella-type shape to enhance the separation of the precipitate, or the intermediate bottom can have separating members that permeate the flow, such as cyclones or slanting or curved pipes that serve as flow channels.

The precipitate, which is separated from the liquid distribution space to the exhaust pipe, can be lead to a clarifier, where the precipitate is separated from the liquid that comes with it, the amount of the liquid generally being about 3-50%, preferably 3-25%, of the total amount of the flow circulated in the evaporator, whereupon the liquid can be returned to the recycled flow.

In the following, the invention is described in detail with the aid of examples and with reference to the appended drawings, in which:

Fig. 1 shows a cross section of an evaporator according to the invention, comprising heat transmission elements made of film material, and liquid circulation channels that have the separation of solid matter arranged in them,

Fig. 2 shows the liquid distribution trough of the evaporator in section II-II of Fig. 1,

Fig. 3 shows, like Fig. 2, the liquid distribution trough according to another embodiment of the invention,

Fig. 4 is the horizontal section IV-IV of Fig. 3,

Fig. 5 shows the lower part and the intermediate bottom, provided with precipitate separation members, of the liquid distribution trough in accordance with a third embodiment of the invention,

Fig. 6 shows a fifth embodiment of the invention, where parallel distributive nozzles are connected to a tubular liquid distribution space to feed liquid to the heat transmission surfaces of the elements, and

Fig. 7 is the section VII-VII of the pipe and the distributive nozzle according to Fig. 6.

Evaporator 1 according to Fig. 1 comprises a cylindrical jacket 2 and parallel, bag-like heat transmission elements 3 made of plastic film and located inside the jacket. In the evaporator, elements 3 are tied into a pack that can consist of several dozens of elements. The evaporation by heat of the solution that is treated takes places on the outer surfaces 4 of the elements; in other words, in the gaps between the elements located against one another. Heat is obtained from the steam that is simultaneously condensed inside the elements. The steam generated by the evaporation can be used as heating steam and it is circulated through a compressor to the supply channels of steam (not shown) leading inside the elements.

The upper end of each bag-like heat transmission element 3 comprises a lath 5 that is suitably cast from plastic, containing channels 6 for feeding the liquid to be evaporated to the film surfaces between the elements to run downwards from above. By using vertical, winding joints 7, the interior of element 3 is divided into channels that direct the flow of the heating steam and the condensate generated by it towards a discoidal condensate eliminator 8 located at the lower end of the element and jointed inside the element. Bottoms 9 of adjacent elements 3 on both sides of condensate eliminator 8 remain sufficiently apart from one another, so that they allow the precipitate, which was formed in the gaps between the elements in connection with the evaporation or other solid matter that came along with the

solution that was evaporated, to fall onto the bottom of the evaporator, where also solution 10 that did not evaporate accumulates.

As at each time of evaporation only a small portion of the solution to be evaporated is converted into steam, evaporator 1 comprises equipment that can be used to repeatedly recycle the solution that has not evaporated back to film surfaces 4 of the elements for re-evaporation. The equipment in question consists of recirculation line 11 that starts from the bottom of the evaporator, combined with line 12, which brings new solution to be evaporated in the evaporation process, pump 13, interior liquid distribution trough 14 of evaporator jacket 2, dam plate 15 that is located in the trough and works as an overflow threshold, and the supply channels 6 of liquid at the upper ends of the elements that we already mentioned. The purpose of the liquid distribution trough 14 is to provide as even a distribution of the solution fed to the evaporation as possible between channels 6 belonging to various elements 3. The solution is supplied onto the film surfaces 4 of the elements symmetrically from the liquid distribution troughs 14 on both sides of the elements, of which, however, only one is shown in detail in Fig. 1.

Fig. 2 illustrates best the structure of liquid distribution trough 14, which, according to the invention, also works as the separator of the precipitate or other solid matter that comes with the recycled solution. Trough 14 is provided with a number of parallel, slanting lamellas 16, which divide the trough into a lower and upper part 17, 18. According to the figure, inlet conduit 11 for the solution, which is downwards curved, joins with the lower part 17 of the trough, the bottom 19 of which slants towards exhaust piping 21 for the precipitate that starts from the opposite side to the mouth 20 of the circulation line of the trough. Parallel lamellas 16 are slanted towards the incoming direction of the solution so that, in accordance with the arrows in Fig. 2, the flow must wind more than 90° in order to get to flow channels 22 between the lamellas, which are directed obliquely upwards. In this condition, solid matter 23, which comes with the solution, can be separated from the stream flow partly under the effect of its own kinetic energy, i.e., centrifugal force, and partly under the effect of gravitational force, and allowed to sediment towards exhaust piping 21 that starts from the bottom of the trough. By adjusting the rate of flow, the process of flow can be kept, in a laminar and sufficiently slow state, in the lower part 17 of the trough, in the gaps between lamellas 16, so that lamellas 16, which work like clarifiers, ultimately prevent the solid matter from getting to the upper part 18 of the trough, at least not to an adverse extent. In the upper part of the trough, dam plate 15 converts the stream flow, which goes into supply channels 6,

into a turbulent form, further decreasing the risk of blocking in the narrow supply channels 6 that are divided into numerous branches (cf. Fig. 1).

In addition to the precipitate, liquid is removed from liquid distribution trough 14 into pipe 21; the amount of the liquid can vary within 3-50% of the flow coming to the trough through recirculation line 11. According to Fig. 1, the final separation of the precipitate from solid matter takes place in lamellate settling apparatus 24, from where the precipitate is removed into line 25 and the liquid is returned through line 26 to the suction face of circulation pump 13. From time to time, precipitate can be removed by rinsing with the valves of lines 21 and 26 being closed.

Figs. 3 and 4 show liquid distribution trough 14 of the evaporator, which differs from the one in Fig. 2 in that the trough has a flat bottom but it narrows in a V shape from mouth 20 of the recirculation line towards the opposite side of the trough, and that instead of slanting lamellas, the trough comprises intermediate bottom 27 comprising crooked pieces of pipe 28 that work as precipitate separators, allowing liquid to flow through. Gravitational force and the centrifugal force acting in the curved inlet conduit 11 press the precipitate towards the outer circumference of the curve and the bottom of trough 14, so that the majority of the precipitate drift directly to exhaust pipe 21 under the effect of its kinetic energy. The stream flow is directed to the said precipitate separators, where gravitational force separates the precipitate remaining in the flow, while the stream flow continues, through the lateral openings 29 at the upper ends of the separators, to the upper part 18 of liquid distribution trough 14. The flow rate in all pieces of pipe 28 is essentially the same because of the narrowing shape of trough 14.

In the application of liquid distribution trough 14 shown in Fig. 5, the crooked pieces of pipe 28 according to Fig. 3 are replaced with L-shaped projections 30 bordering the flow-through openings in intermediate bottom 27. Otherwise, the application in Fig. 5 corresponds to what is described above.

Figs. 6 and 7 show an application of the invention, where liquid distribution space 14 consists of a pipe with an essentially round cross-section, which is an extension of inlet conduit 11. According to Fig. 7, pipe 11 forms a curve, where centrifugal force presses the solid matter contained by the liquid to the outer circumference of the curve, and further to the bottom of liquid distribution space 14, from where the solid matter ends up in exhaust pipe 21. Parallel distributive nozzles 31 are attached to liquid distribution space 14, distributing the liquid, which is mainly purified of solid matter, to liquid channels 6 contained by end laths 5 of the parallel heat

transmission elements 3. Tips 32 of distributive nozzles 31 extending inside liquid distribution space 14 are bevelled to form an angle α, which is suitably about 10-35°, and the nozzles expand in a fan-like shape, so that each one of them feeds liquid to several adjacent elements 3. Furthermore, distributive nozzles 31 are provided with inner baffle plates 33 to ensure an even distribution of liquid.

It is obvious to those skilled in the art that the various embodiments of the invention are not limited to the examples described above, but can vary within the following claims. Thus, the separation of precipitate according to the invention can be applied not only in the film evaporators described above but also in traditional evaporators comprising metal heat transmission elements.

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Claims

1. A method of evaporating a solution, comprising feeding the solution to heat transmission surfaces (4) of parallel plate-formed heat exchanger elements (3) of an evaporator (1), from supply units (6, 31) spreading the solution to the top of said surfaces to flow downwards, removing the part of the solution (10) remaining from the evaporation and precipitate formed in connection with the evaporation from the lower end of the evaporator, and recycling said remaining part of the solution (10) back to the heat transmission surfaces (4) for re-evaporation, said recycling comprising conducting the solution to a liquid distribution space (14) common to said heat exchanger elements (3), separating the precipitate (23) from the solution in said distribution space, the solution forming an upward flow in the distribution space, and passing the solution to said supply units (6, 31) for being spread onto the heat transmission surfaces (4), characterized in that the recycled solution is fed to the liquid distribution space (14) from a downwardly curved conduit (11) as a curved flow, to separate the precipitate (23) under the combined effect of gravity and centrifugal force, and the precipitate as separated is discharged to an exhaust pipe (21) from the bottom of the liquid distribution space.

2. A method according to Claim 1, **characterized** in that the solution to be recycled is fed into a narrow, elongated liquid distribution space (14) from its one end, and that the precipitate is removed into an exhaust pipe (21) from the opposite end of the space.

3. A method according to any of the preceding Claims, **characterized** in that the solution to be recycled is fed underneath parallel lamellas (16) or an intermediate bottom (27) provided with ports (28-30), which are located in the liquid distribution space (14), so that the flow of the solution winds towards the ports of the intermediate bottom or the flow channels (22) between the lamellas, and the precipitate (23) is separated from the flow under the effect of centrifugal force.

4. A method according to any of the preceding Claims, **characterized** in that the precipitate is lead through an exhaust pipe (21) to a settling apparatus (25), where the precipitate is separated from the liquid phase that comes with it, after which the liquid phase is connected to the recirculation flow of the solution that takes place in the evaporator.

5. A method according to any of the preceding Claims, **characterized** in that the evaporator is a film evaporator consisting of heat exchanger elements (3) made of flexible film material, such as plastic film.

6. An evaporator (1) comprising a jacket (2), parallel upright plate heat exchanger elements (3) fitted inside the jacket, said elements having upright heat transmission surfaces (4), supply units (6, 31) for spreading a solution to be evaporated to the top of said heat transmission surfaces to flow downwards on said surfaces, a liquid distribution space (14) common to said heat exchanger elements for feeding the solution to said supply units, means for removing the part of the solution (10) remaining from the evaporation and precipitate formed in connection with the evaporation from the lower end of the evaporator and for recycling said remaining part of the solution (10) back to the heat transmission surfaces (4) for re-evaporation, said recycling means comprising a conduit (11) connecting said lower end of the evaporator with said liquid distribution space (14), said space having means for separating the precipitate (23) from the solution being recycled, characterized in that said conduit (11) for recycling the solution forms a downward curve connected to the liquid distribution space (14), to feed the solution to said space as a curved flow and to separate the precipitate (23) under the combined effect of gravity and centrifugal force, and that an exhaust pipe (21) for discharging the precipitate as separated starts from the bottom of the liquid distribution space.

7. An evaporator according to Claim 6, **characterized** in being a film evaporator consisting of heat exchanger elements (3) made of flexible film material, such as plastic film.

8. An evaporator according to Claim 6 or 7, **characterized** in that the liquid distribution space (14) is located inside the evaporator jacket (2).

9. An evaporator according to any of Claims 6 to 8, **characterized** in that the recirculation line (11) is attached to one end of the elongated liquid distribution space (14), and that the exhaust pipe (21) for the precipitate starts from the opposite end of the liquid distribution space.

10. An evaporator according to any of Claims 6 to 9, **characterized** in that the bottom of the liquid distribution space (14) is slanted downwards towards the exhaust pipe (21).

11. An evaporator according to any of Claims 6 to 10, **characterized** in that the liquid distribution space (14) converges in a sphenoid or conic form towards the exhaust pipe (21).

12. An evaporator according to any of Claims 6 to 11, **characterized** in that the supply units comprise distributive nozzles (31) that start from the liquid distribution space (14) and spread out like fans, each one of them feeding solution to several parallel gaps between the heat transmission surfaces (4) of the heat exchanger elements (3), evaporation taking place in the gaps.

13. An evaporator according to any of Claims 6 to 12, **characterized** in that the trough-like liquid distribution space (14) is provided with parallel, slanting lamellas (16), between which the solution is allowed to flow upwards.

14. An evaporator according to any of Claims 6 to 12, **characterized** in that the trough-like liquid distribution space (14) comprises an intermediate bottom (27) that divides it into a lower and upper part (17, 18), that the recirculation line (11) is attached, in the lateral direction, to the lower part (17) of the liquid distribution space, and that the intermediate bottom comprises ports, through which the solution is allowed to flow to the upper part (18) of the space at the same time as the precipitate (23) ends up in the exhaust pipe (21) that starts from the bottom of the space.

15. An evaporator according to Claim 14, **characterized** in that the flow routes formed by the openings in the intermediate bottom (27) are slanted upstream with regard to the incoming direction of the recirculation flow.

16. An evaporator according to any of Claims 13 to 15, **characterized** in that the trough-like liquid distribution space (14) is provided with a dam plate (15), over which the solution flows as an overflow to the supply units (6) of the parallel heat exchanger elements.

17. An evaporator according to any of Claims 6 to 16, **characterized** in that the exhaust pipe (21) leads to a settling apparatus (24), which separates the precipitate from the liquid phase that comes with it, and that the settling apparatus is connected, by using a line (26), to the recirculation line (11) in order to join the separated liquid phase to the recirculation flow in the evaporator.

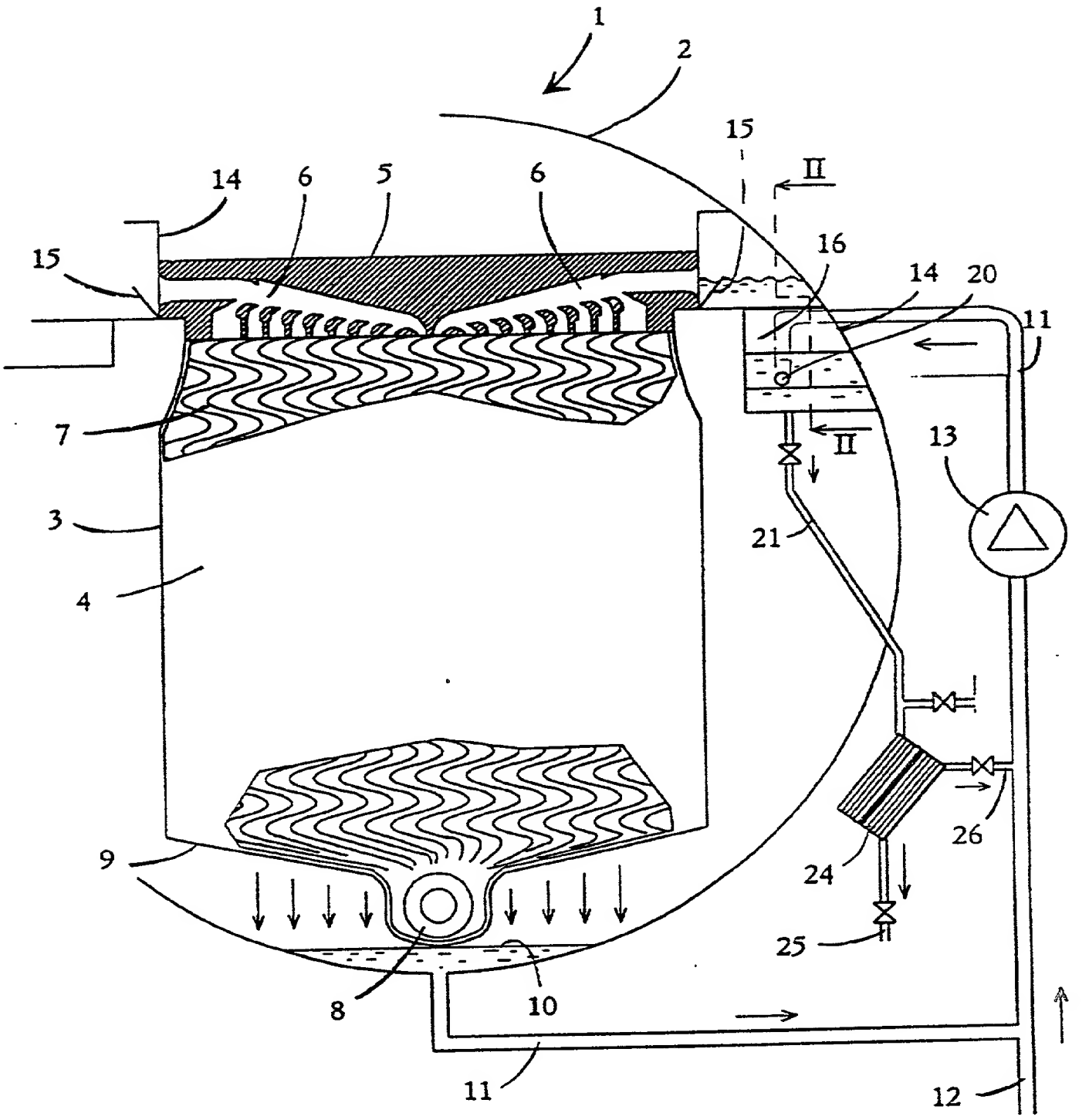

Fig. 1

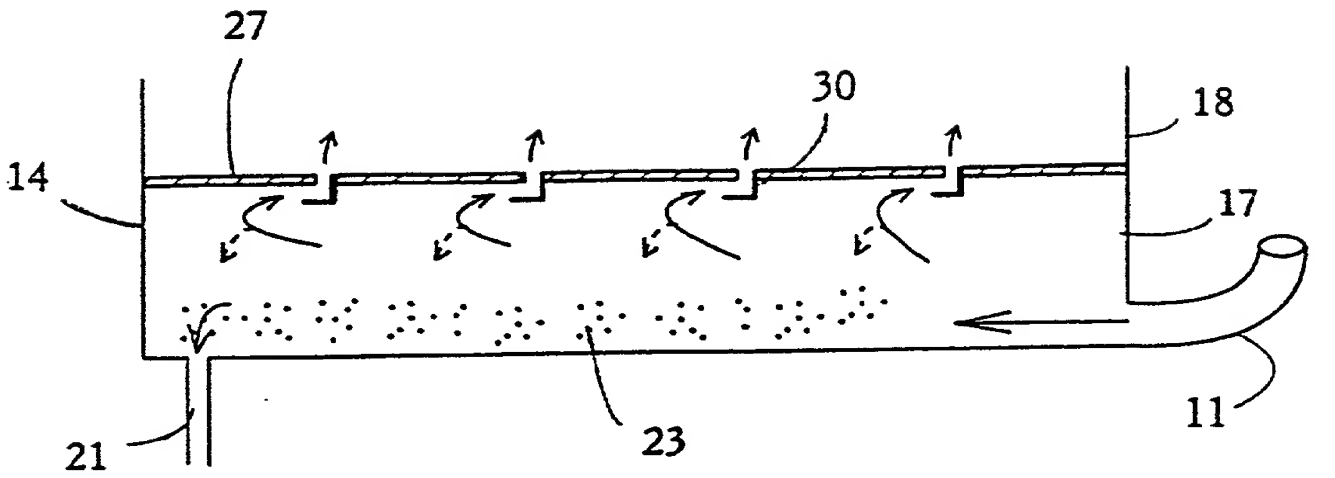

Fig. 5

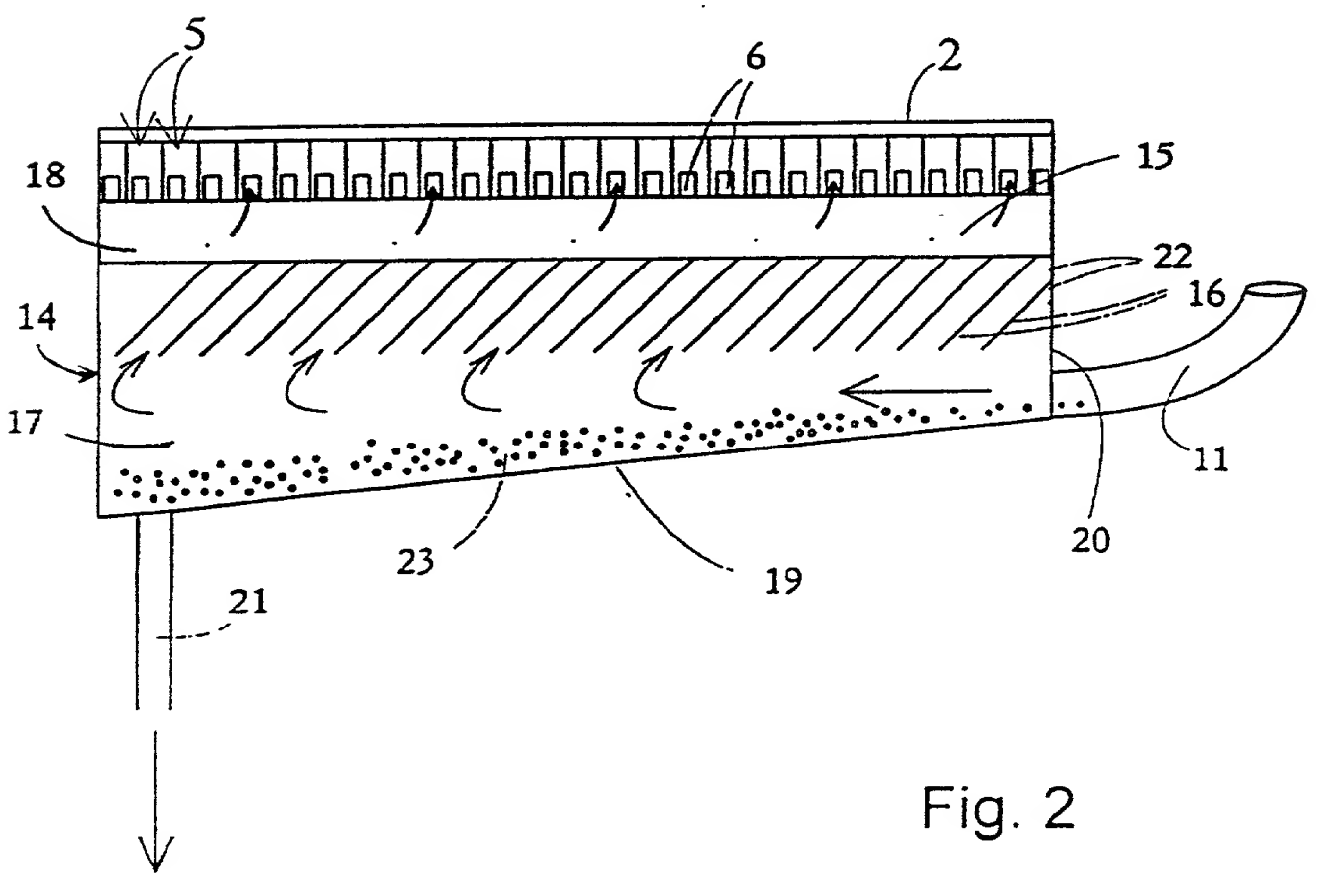

Fig. 2

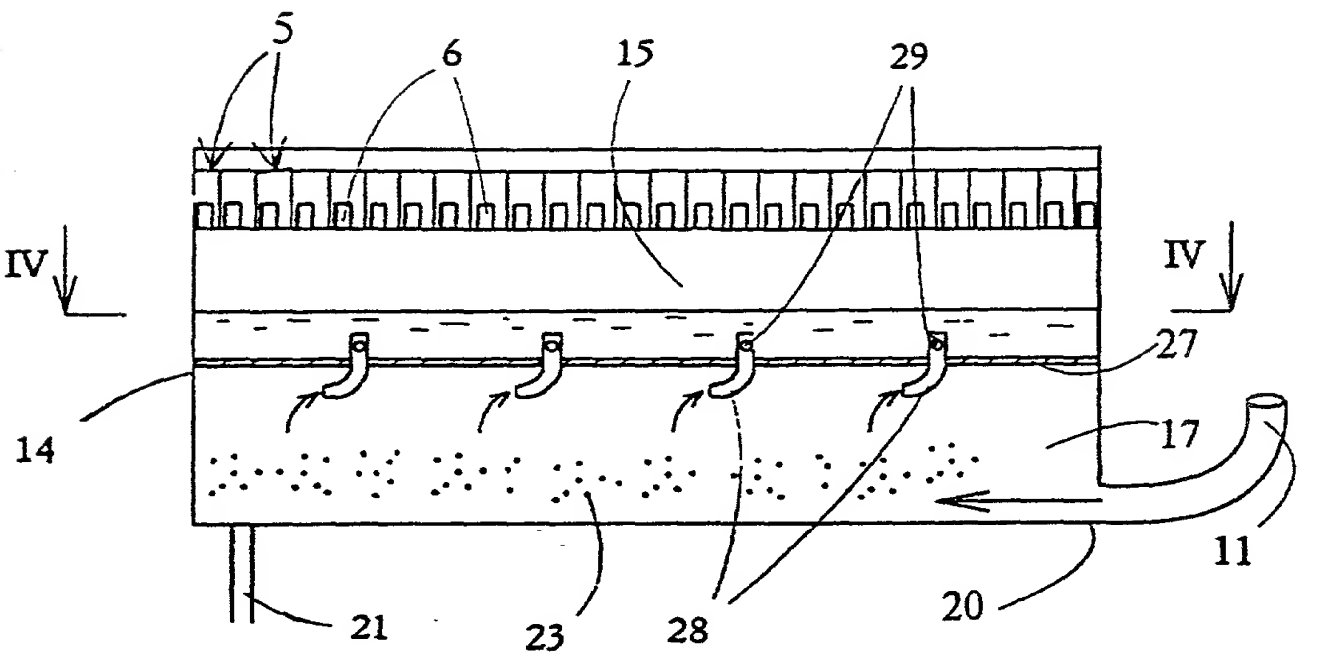

Fig. 3

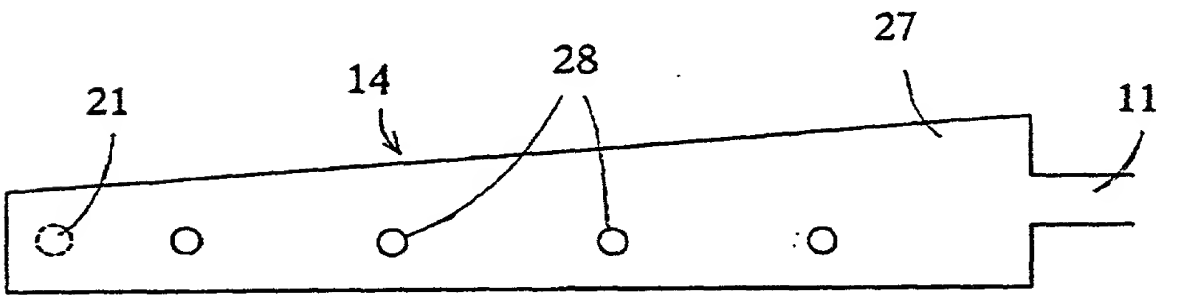

Fig. 4

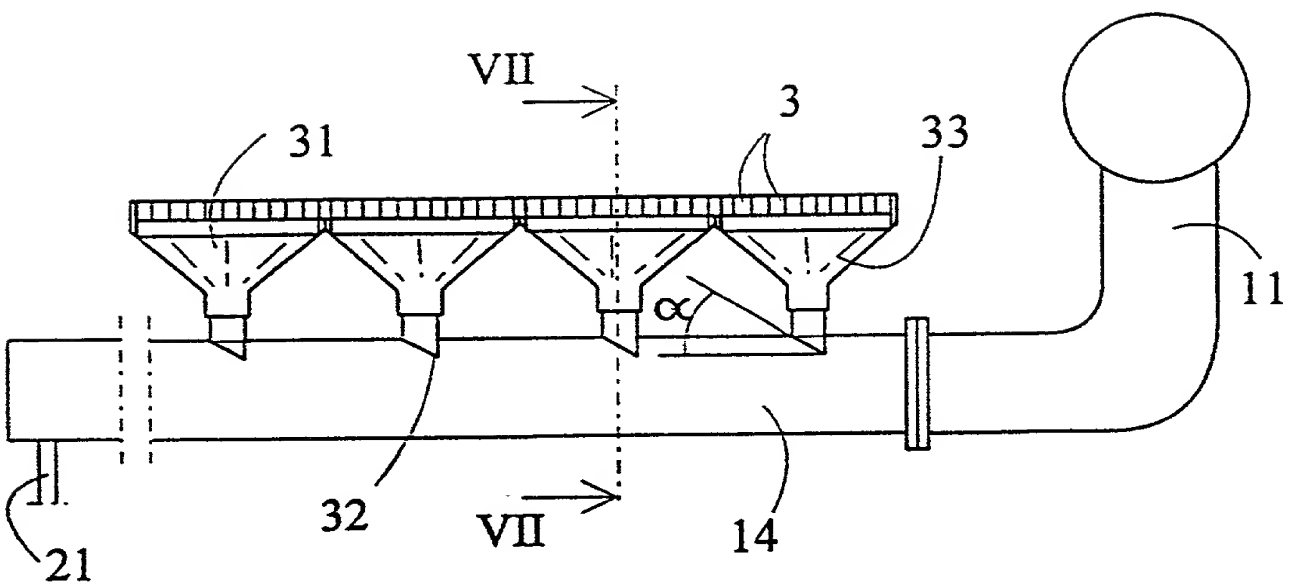

Fig.6

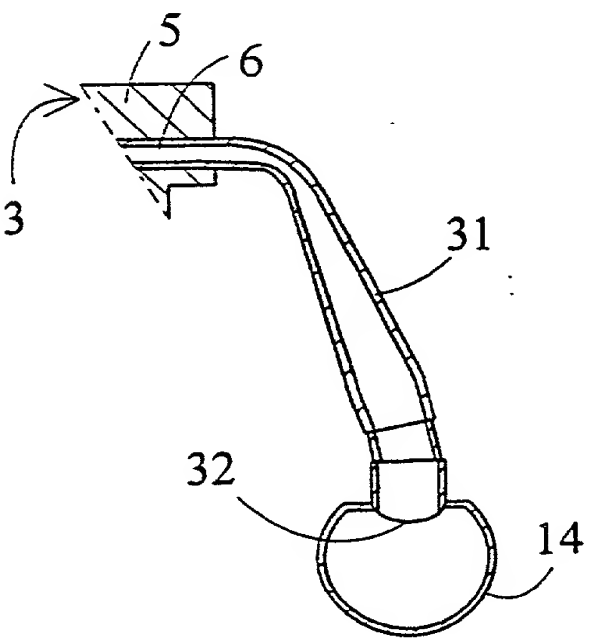

Fig. 7

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Attorney Docket No.

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PLEASE NOTE: YOU MUST COMPLETE THE FOLLOWING

COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT AND DESIGN APPLICATIONS

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated next to my name; that I verily believe that I am the original, first and sole inventor (if only one inventor is named below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Insert Title: A process for evaporating a solution and an evaporator for use in the process

Fill in Appropriate Information - For Use Without Specification Attached:

the specification of which is attached hereto. If not attached hereto,
the specification was filed on 1 October 2001 as
United States Application Number 09/937904
and amended on _____ (if applicable) and/or
the specification was filed on 31 March 2000 as PCT
International Application Number PCT/FI00/00278; and was
amended under PCT Article 19 on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I do not know and do not believe the same was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representative or assigns more than twelve months (six months for designs) prior to this application, and that no application for patent or inventor's certificate on this invention has been filed in any country foreign to the United States of America prior to this application by me or my legal representatives or assigns, except as follows.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Insert Priority Information: (if appropriate)

Prior Foreign Application(s) (Number)	(Country)	(Month/Day/Year Filed)	Priority Claimed
990735	Finland	1 April 1999	☒ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional applications(s) listed below.

Insert Provisional Application(s): (if any)

(Application Number)	(Filing Date)

All Foreign Applications, if any, for any Patent or Inventor's Certificate Filed More than 12 Months (6 Months for Designs) Prior to the Filing Date of This Application:

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Country	Application Number	Date of Filing (Month/Day/Year)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States and/or PCT application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States and/or PCT application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to the patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Insert Prior U.S. Application(s): (if any)

(Application Number)	(Filing Date)	(Status - patented, pending, abandoned)

Attorney Docket No.

I hereby appoint the practitioners at CUSTOMER NO. 2292 as my attorneys or agents to prosecute this application and/or an international application based on this application and to transact all business in the United States Patent and Trademark Office connected therewith and in connection with the resulting patent based on instructions received from the entity who first sent the application papers to the practitioners, unless the inventor(s) or assignee provides said practitioners with a written notice to the contrary:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Residence (City, State & Country)		CITIZENSHIP
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Rev. 10-2000

*DATE OF SIGNATURE